Abstract— Optical Coherence Tomography (OCT) is a relatively new, high resolution, non-invasive imaging method which was applied for the first time in ophthalmology. It is rapid, easy to perform and analyze, very comfortable for the patients and it offers detailed information about the ocular structures, allowing early diagnosis and treatment in a variety of ocular conditions. The description of Spectral Domain OCT principle is followed by the presentation of the investigation capabilities, technical characteristics and examination modules belonging to the Spectralis device (Heidelberg Engineering). The contribution of this modern investigation tool in the clinical practice is illustrated with cases from the personal experience.

Keywords— Spectral Domain OCT, Age related Macular Degeneration, Vitreo-Macular Interface Syndrome, Diabetic Macular Edema.

I. INTRODUCTION

Optical Coherence Tomography (OCT) is a high resolution, non-invasive imaging method that started to be used in the clinical practice in 1990s. The first application of OCT technology was in the field of ophthalmology and the images resembled the histological sections of the retina. However, the pictures depict the result of the scanned tissues’ optical properties, not the tissues themselves [1].

OCT concept developed at Massachusetts Institute of Technology, at the beginning of 1990s. The first commercial device was made by Carl Zeiss (Jena, Germany) in 1996. The first OCT applications referred to quantitative and qualitative information about the peripapillary area of the retina and the coronary arteries [2].

OCT uses light, as opposed to ultrasonic biomicroscopy (UBM) that uses ultrasounds, with the aim to visualize eye structures. Light speed is 1 million times higher than sound speed. By consequence, resolutions lower than 10 μ microns are obtained in the posterior pole of the eye with OCT technology. For many years, UBM offered resolutions in the range of 150 microns, whereas in SD-OCT, 65,000 scans are made within an area of 6 mm diameter. Acquisition time is about 60 times faster with SD-OCT devices and the axial resolution varies between 3 - 7 μ, as compared to TD-OCT (10 - 15 μ) [3].

Eye tracking function is used to neutralize the errors induced by involuntary eye movements. Spectralis is able to detect changes within 1 - 2 microns, at the depth of 289 microns, and it is able to filter and select the high resolution images, in order to identify the finest details. The auto re-scan function is very important for the patient's follow-up, as it places the subsequent scans precisely at the initial examination site. The deep layers can be examined with the enhanced-depth OCT function (EDI-OCT) [3].

II. DESCRIPTION OF THE DEVICE

A. Overview

Spectralis is a multimodal platform that uses the confocal laser technology, in order to obtain color and spectral optical coherence tomography (OCT) images of the eye structure. Two different laser wavelengths catch simultaneously, the OCT and the fundus image of the eye [3].

The principle of Spectral Domain OCT (SD-OCT) is based on the Fourier equation, as compared to Time Domain OCT (TD-OCT) that developed on the ground of interferometry. In TD-OCT, an interferometer measures sequentially, the delay of light echoes that are reflected by the retinal microstructures. In SD-OCT, a spectrometer evaluates simultaneously, the light reflected by retinal microstructures. In TD-OCT, 6 radial scans are performed, whereas in SD-OCT, 65,000 scans are made within an area of 6 mm diameter. Acquisition time is about 60 times faster with SD-OCT devices and the axial resolution varies between 3 - 7 μ, as compared to TD-OCT (10 - 15 μ) [3].

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B. Investigation possibilities

Spectralis offers the following imaging possibilities for the eye: spectral domain OCT (SD-OCT), infrared (IR), red free, fundus autofluorescence (FAF), confocal multicolor 3D, wide field (55°), SD-OCT for the diagnosis and monitoring of glaucoma, anterior segment imaging [3].

C. Technical characteristics

Domain: Spectralis operates in the spectral domain OCT, based on the Fourier equation.

Minimal scan speed: 40000 A-scans /second
Laser light sources:
A super luminescent diode $\lambda$ 870 nm acquires the images. IR light ($\lambda$ 815 nm) allows the visualization of detailed images of the eye fundus.

A green laser ($\lambda$ 518 nm) ensures the obtaining of confocal, 3D images of the retina, with multicolor technology.

A blue laser ($\lambda$ 486 nm) is used for identifying fundus auto fluorescence (FAF) and obtaining the red free images. The blue light makes it possible to identify fundus auto fluorescence, based on the fluorescent properties of lipofuscin. With red free light, specific structures are visualized: nerve fiber layer, epiretinal membranes and retinal cysts.

The simultaneous, confocal, 3D collection of the imaging data with three different types of lasers (red, green and blue) allows to evaluate various retinal layers on a single image.

The device also offers the possibility to combine the above mentioned acquiring modalities, in various ways, according to the investigated retinal condition: IR and FAF, OCT and IR, OCT and FAF, OCT and red free, OCT and 3D multicolor confocal eye fundus examination [3].

D. Examination modules

Anterior segment: By the use of a high resolution 3D examination lens, images with 7 $\mu$m axial resolution and 30 $\mu$m lateral resolution can be obtained. The scanning depth in the tissue is of 1.9 mm.

Multicolor confocal 3D module: It allows the visualization of the 3D, color image of the eye fundus, simultaneously with the transverse section through the retina. Thus, different retinal structures are evaluated on one single image. Scanning with multiple laser wavelengths allows the detailed evaluation of the retinal structure: superficial, middle and deep retinal layers.

Wide field module: It makes possible to view the retinal periphery, by OCT and fundus image, using a non-contact, 55˚ lens. The high resolution visualization of the macula, optic nerve and retinal periphery is achieved in a single image. The scanning models are: radial 55˚ central and volume 55°x25° (for the diabetic patients) /55°x40° /25°x5° central.

Glaucoma module: It allows the complete analysis of glaucoma, with the evaluation of the neuro-retinal rim, retinal nerve fiber layer (RNFL) and asymmetry regarding the posterior pole and the ganglion cell layer.

The optic nerve head (ONH) analysis is made using the Bruch's membrane opening as the anatomical frontier for the rim. The neuro-retinal rim is measured between Bruch's membrane opening and the nearest point of the internal limiting membrane (ILM).

During scanning, the device lines up automatically, the fovea with the central axis of Bruch's membrane opening.

Future scans and sectors are placed exactly on the previous sites, which is very important for the accurate monitoring of the disease progression.

Various scans are available: 24˚ radial scan, circular scans with 3.5 mm/4.1 mm/4.6 mm diameter, volume scans of 30°x25°/30°x15° /15°x15°, circular scan of the RNFL at 12°, with 768 analyzed points [3].

III. SPECTRALIS OCT IN THE DIAGNOSIS AND MONITORING OF MACULAR DISORDERS

Optical Coherence Tomography is widely used in the assessment and monitoring of macular diseases. We illustrate the contribution of Spectralis in the clinical practice with selected cases from our own experience. The patients were included in this study in accordance with the Helsinki Declaration of 1975, as revised in 2000 and 2008.

A. Age related Macular Degeneration (AMD)

AMD is one of the retinal conditions that benefited the most from the progress in of OCT technology. The main advantage of the OCT imaging is the quantification of the retinal thickness, allowing to monitor the anti-VEGF treatment efficacy in wet AMD. OCT is also able to identify the location of the fluid in neovascular AMD: intraretinal, sub-retinal and sub-Retinal Pigmented Epithelium (RPE) [4].

According to OCT imaging, the choroidal neovascular membranes (CNV) in wet AMD were classified into 3 types. In type 1 (occult neovascularization), CNV is located under the retinal pigmented epithelium (RPE), in type 2 (classic neovascularization), it is located above the RPE and in type 3, there is a retinal angiomatous proliferation (RAP). In large RPE detachments, breaks in the RPE layer can occur. The rupture of the RPE layer appears as a clearly demarcated region of RPE absence, adjacent to a region of RPE elevation. The reversed shadow effect is identified. Often, especially in type 2 CNVs, the interruption of the RPE layer is identified. In type 2 CNV, the neovascular membrane is located in the subretinal space and it penetrates through the RPE/Bruch's membrane complex. RAP is a rare form of wet AMD that originates in abnormal neovascular tissue from the deep retinal layers [5].

The response to anti-VEGF therapy is translated into the OCT imaging, by the diminishing/disappearance of the intra/sub-retinal fluid and by the decrease of the PEDs size and of the macular thickness [2].